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(71) Applicant:
Machining Centers Manufacturing S.p.A.
29020 Vigolzone (PC) (IT)

(72) Inventors:
- **Bolledi, Giuseppe**
  29028 Ponte Dell'Olio (PC) (IT)
- **Bertuzzi, Massimo**
  29010 Gazzola (PC) (IT)

(74) Representative: **Carloni, Franco**
c/o Calvani, Salvi & Veronelli S.r.l.,
Piazza Duca d'Aosta, 4
20124 Milano (IT)

(54) Shock-absorbing device for spindle headstocks

(57) The shock-absorbing device is intended to be mounted on the spindle headstock (10) of a machine tool. The spindle headstock (10) includes a motor driven spindle unit (11) connected to an upright by means of a support (12). The device comprises a yieldable structure (14,20) connected on the one side to the spindle unit (11) and on the other side to the support (12) and adapted to yield upon an accidental collision of the spindle headstock (10) against a workpiece. Collision sensor means are associated to the yieldable structure (14,20) for detecting the yielding thereof resulting from an accidental collision of the spindle headstock (10) against a workpiece and for transmitting in response a signal to a machine tool control unit.

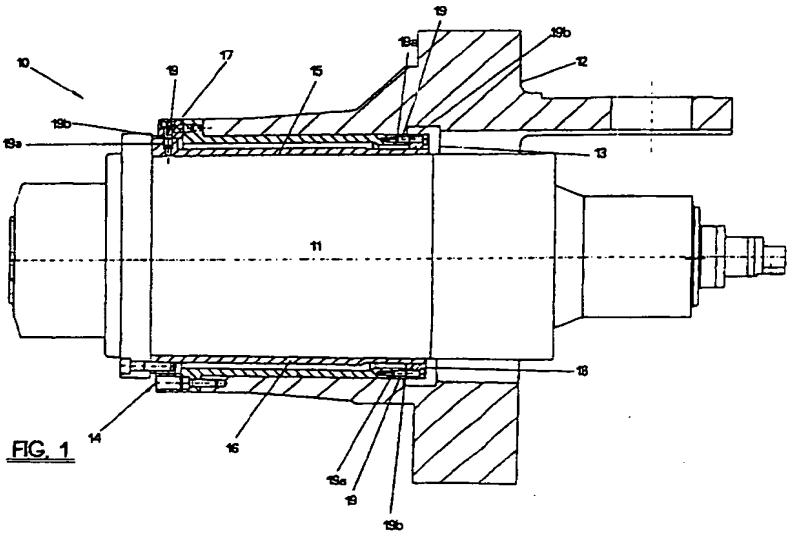

FIG. 1

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Description

[0001] The present invention generally relates to metal cutting machine tools and, more particularly, a device for protecting the spindle headstock of a machine tool in the case of an accidental collision against a workpiece.

[0002] As known, in recent years manufacturers in the field of machine tools have directed their efforts to improve, in addition to the quality of machining, also the efficiency of machine tools by gradually and continuously reducing machine time and machine setup time.

[0003] At present, machine time has becomed reduced thanks to the improvements to the quality of the cutting edges of tools and, in particular, to their wear resistance and, furthermore, because the cutting speed has increased.

[0004] Machine tool manufacturers are now endeavoured to reduce in the work cycle the machine tool setup time which relates to the retooling operations, workpiece loading and unloading operations, workpiece dimensional check operations and, not in the least, positioning operations of the spindle headstock in the various machining configurations required.

[0005] It can be clearly understood that a reduction of the machine tool setup time is especially important in the case of a 24-hour work cycle wherein few minutes lost in the machine tool setup operation during the production of a workpiece, once they are multiplied by the daily production, can result in the lost of several hours.

[0006] Since each hour lost in the machine tool setup operation has a negative effect on the returns the invested capital must yield, the importance of reducing the machine tool setup time to a minimum is clearly understood.

[0007] For this reason, the current tendency of machine tool manufacturers is to use movable spindle headstocks having very high feed speeds. In particular, the time required for positioning the spindle headstock has been greatly reduced by increasing the feed speed of the spindle headstock to a top limit of 80 m/min using more and more improved drives.

[0008] On the one hand the increase in the feed speed of the spindle headstock permits a great amount of machine tool setup time to be saved, but on the other hand it exposes the spindle headstock to the risk of colliding against the workpiece as a result of a wrong control, an excessive delay of the response to a control or an inaccurate positioning.

[0009] It must be taken in account that because of the inertia and speed involved, in the event of a collision, forces of great intensity would be developed and the resulting decrease of kinetic energy would be converted into internal energy which would be absorbed and dissipated in the workpiece and the spindle headstock, thus causing great damage to both and especially to the latter.

[0010] Therefore, any damage to the spindle headstock resulting from a collision against the workpiece must be absolutely avoided because the spindle headstock is one of the most easily damaged and accurately designed, and thus also expensive parts of the machine tool.

[0011] It is therefore an object of the present invention to reduce to a minimum the damages to the spindle headstock caused by an accidental collision against a workpiece during the positioning of the spindle headstock in an operative work configuration.

[0012] According to the invention, this object is achieved by means of a shock-absorbing device for the spindle headstock of a machine tool, wherein the spindle headstock includes a motor driven spindle unit connected to an upright by means of a support, characterised in that the spindle headstock comprises:

- a yieldable structure connected on the one side to the spindle unit and on the other side to the support and adapted to yield upon an accidental collision of the spindle headstock against a workpiece, and
- collision sensor means associated to said yieldable structure for detecting the yielding thereof resulting from an accidental collision of the spindle headstock against a workpiece and for transmitting in response a signal to a machine tool control unit.

[0013] The features and the advantages of the present invention will be clearly understood from the following detailed description given here for explanatory purposes only and without limitation to its extent with reference to the accompanying drawings, wherein:

Fig. 1 is a side elevation and partial section view of a first preferred embodiment of the spindle headstock of the invention, and
Fig. 2 is a side elevation and partial section view of a second preferred embodiment of the spindle headstock of the invention.

[0014] As there can be seen from Figs. 1 and 2 of the drawings, according to both the embodiments of the invention, the spindle headstock, generally designated by 10, comprises an electric motor driven spindle unit 11 and a support 12 for firmly supporting the spindle unit 11 and securing it to an upright (not shown) of the machine tool.

[0015] The support 12 is provided with a substantially cylindrical shaped housing 13 adapted to receive the spindle unit 11.

[0016] According to the invention, for connecting the spindle unit 11 to the support 12 a special shock-absorbing device is provided which is capable of permitting the spindle unit 11 to retract inside its housing 13 in the case of a collision against a workpiece and at the same time to provide an input signal to be transmitted to a machine tool control unit informing that a collision has occurred and that the machine tool must be stopped by

decreasing the rotational speed of the spindle. The shock-absorbing device is arranged between the spindle unit 11 and the support 12 and can have different embodiments.

[0017] In a first preferred embodiment of the invention, shown in Fig. 1 of the accompanying drawings, the shock-absorbing device is designated by 14 and is represented in a longitudinal section. The shock-absorbing device 14 is formed of two coaxial and spaced-apart tubular elements 15 and 16, the element 15 being secured to the spindle unit 11, whereas the element 16 is secured to the support 12.

[0018] The two tubular elements 15 and 16 are connected to each other at their ends by means of two connecting annuli 17 and 18, respectively.

[0019] The shock-absorbing device 14 is configured so as to be capable of absorbing the energy involved in an accidental collision between the spindle unit 11 and a workpiece by deformation or moreover by breakage if during the collision it is subjected to a load greater than normal.

[0020] For this purpose, the two connecting annuli 17 and 18 are connected to the tubular elements 15 and 16 by means of screws 19, which have a rated breaking load. As known, the screws of this kind are adapted to break when they are subjected to a load greater than their rated breaking load. For this purpose, a V-shaped notch 19b is made in the screw shank 19a for reducing the resistance of the screw so as to cause it to break when it is subjected to a tensile or shear stress having an intensity greater than the corresponding limit values as it generally occurs in the case of a collision between the spindle unit 11 and a workpiece.

[0021] In the event of such a collision, the breaking of the screws 19 with rated breaking load permits the spindle unit 11 to retract inside the housing 13 and, therefore, to drive the tool spindle away from the workpiece.

[0022] In order to detect the breakage of the screws 19 with rated breaking load, in at least one thereof a longitudinal bore is provided through which a breakage detecting means passes. Such means can be formed f.i. of a fluid under pressure. When breakage of the screw 19 occurs, the resulting pressure change is sensed and converted by a transducer into an output signal to be transmitted to a closed-loop machine tool control unit of the spindle headstock 10. In the retraction of the spindle unit 11 inside the housing 13, the machine tool control unit causes the rotational speed of the tool spindle to be gradually reduced until operation of the machine tool is stopped.

[0023] Referring now to Fig. 2 of the drawings, there is shown a second embodiment of the shock-absorbing device according to the present invention. According also to this second embodiment, the shock-absorbing device, in this case designated by 20, is formed of two coaxial and spaced-apart tubular elements 21 and 22, where the element 21 is secured to the spindle unit 11 and the element 22 is secured to the support 12.

[0024] The tubular element 21 is firmly maintained in position around the spindle unit 11 by means of an attachment 23. This attachment 23 is provided at one end of the tubular member 21, integrally therewith, and is secured to the spindle unit 11 by means of screws 24.

[0025] The tubular element 22 is secured to the support 12 by means of screws 25 and a sleeve 26 extending beyond the tubular member 22 and into engagement against the attachment 23 of the tubular element 21 is inserted inside the tubular member 22 coaxial thereto and axially movable therein. An annulus 27 connected to the tubular element 22 by means of screws 28 acts as a stop for the sleeve 26.

[0026] An annulus 29 is connected by means of screws 30 to the free end of the tubular element 21 in order to maintain the spindle unit 11 firmly in position inside the housing 13 of the support 12 during normal work operation of the machine tool. The annulus 27 secured to the tubular element 22 contacts the annulus 29.

[0027] The coaxial and spaced-apart tubular elements 21 and 22 define a substantially cylindrical closed chamber 31 which is filled with fluid under pressure.

[0028] The so configured shock-absorbing device 20 is capable of absorbing by deformation the energy involved during an accidental collision between the spindle unit 11 and a workpiece and operates according to the following principle.

[0029] During normal work operation of the machine tool, the shock-absorbing device maintains the spindle unit firmly in position because of the mutual engagement of the tubular elements 21 and 22. As already said, the chamber 31 is closed and is filled with a fluid under pressure.

[0030] When the spindle unit is struck suddenly and violently as a result of a collision against a workpiece, the spindle unit 11 retracts inside the housing 13 of the support 12 and at the same time urges the sleeve 26 backwards. As a result of the retraction of the spindle unit 11, the annulus 29 desengages from the annulus 27 thus causing the chamber 31 to open and the fluid contained under pressure therein to flow out.

[0031] The resulting fluid pressure change is detected by means of a pressure transducer and is converted into an output signal to be transmitted to a closed-loop machine tool control unit of the spindle headstock 10. In the retraction of the spindle unit 11 inside the housing 13, the machine tool control unit causes the rotational speed of the tool spindle to be gradually reduced until the operation of the machine tool is stopped.

[0032] Once the collision between the spindle unit 11 and the workpiece has occurred, the shock-absorbing device 20 can be easily and readily brought back to the initial condition by filling the chamber 31 with the pressurised fluid thereby making its servicing easy and

economical.

[0033] Of course, other yieldable means capable of absorbing and dissipating internally the impact energy resulting from an accidental collision of the spindle headstock against a workpiece in order to protect it can be used instead of the shock-absorbing device shown in the Figures.

[0034] Also the sensor means used for detecting a collision between the spindle headstock and a workpiece can be different from those described above and they can operate according to different principles. For instance, photoelectric sensors, position sensors, etc. can be used as sensor means.

[0035] From the foregoing, it can be understood that the invention accomplishes the proposed object and, in particular, it provides a spindle headstock 10 having a spindle unit 11 connected to a support 12 by the intermediary of a shock-absorbing device 14,20 capable of imparting to the spindle unit 11 the required stability and resistance, together with positioning accuracy, in the normal work operation of the machine tool, and at the same time of absorbing the impact energy involved in an accidental collision between the spindle headstock 10 and a workpiece and of protecting the integrity of the spindle unit 11.

[0036] Such a shock-absorbing device, in its preferred embodiment described above, has a relatively simple configuration and its cost is extremely low compared to that of the spindle headstock as a whole.

[0037] Of course, to the shock-absorbing unit according to the invention various modifications and changes can be made without departing from the inventive idea; furthermore, all the accessory parts can be substituted with other parts that are technically equivalent.

Claims

1. A shock-absorbing device for the spindle headstock (10) of a machine tool, wherein the spindle headstock (10) includes a motor driven spindle unit (11) connected to an upright by means of a support (12), characterised in that the spindle headstock (10) comprises:

   - a yieldable structure (14,20) connected on the one side to the spindle unit (11) and on the other side to the support (12) and adapted to yield upon an accidental collision of the spindle headstock (10) against a workpiece, and
   - collision sensor means associated to said yieldable structure (14,20) for detecting the yielding thereof resulting from an accidental collision of the spindle headstock (10) against a workpiece and for transmitting in response a signal to a machine tool control unit.

2. A shock-absorbing device according to claim 1, characterised in that the yieldable structure (14) is formed of two coaxial and spaced-apart tubular elements (15,16), one (15) of which is secured to the spindle unit (11) and the other (16) to the support (12), and two annular elements (17,18) connecting one tubular element to the other.

3. A shock-absorbing device according to claim 2, characterised in that, in order to cause the yielding of the yieldable structure (14), the two annular elements (17,18) are connected to the two tubular elements (15,16) by elements (19) having a rated breaking load.

4. A shock-absorbing device according to claim 3, characterised in that the elements (19) having a rated breaking load are formed of screws having a shank (19a) provided with a V-shaped annular notch (19b).

5. A shock-absorbing device according to claim 1, characterised in that the yieldable structure (20) is formed of two coaxial and spaced-apart tubular elements (21,22), one (21) of which is connected to the spindle unit (11) and the other (22) to the support (12), said tubular elements (21,22) being mutually engaged so as to form a closed chamber (31) therebetween.

6. A shock-absorbing device according to claim 5, characterised in that, in order to cause the yielding of the yieldable structure (20), the two mutually engaged tubular elements (21,22) are displaceable one with respect to the other so as to cause the opening of the chamber (31) upon an accidental collision of the spindle headstock (10) against a workpiece.

7. A shock-absorbing device according to claims 1 to 3, characterised in that the collision sensor means are of hydraulic or pneumatic kind and they provide a fluid under pressure which is caused to pass through the elements (19) with a rated breaking load and a pressure transducer for converting the pressure change resulting from the breaking of the elements (19) with a rated breaking load following an accidental collision of the spindle headstock (10) against a workpiece into an output signal to be transmitted to the machine tool control unit.

8. A shock-absorbing device according to claims 1 to 3, characterised in that the collision sensor means are of electromagnetic kind and they provide an electromagnetic signal which is caused to pass through the elements with rated breaking load and an electromagnetic transducer for converting an interruption of the electromagnetic signal resulting from the breaking of the elements (19) with rated

breaking load following an accidental collision of the spindle headstock (10) against the workpiece into an output signal to be transmitted to be machine tool control unit.

9. A shock-absorbing device according to claims 1, 5 and 6, characterised in that the collision sensor means are of hydraulic or pneumatic kind and they provide a fluid under pressure contained in the closed chamber (31) defined by the two tubular elements (21,22) and a pressure transducer for converting the pressure change resulting from the opening of the chamber (31) following an accidental collision of the spindle headstock (10) against a workpiece into an output signal to be transmitted to the machine tool control unit.

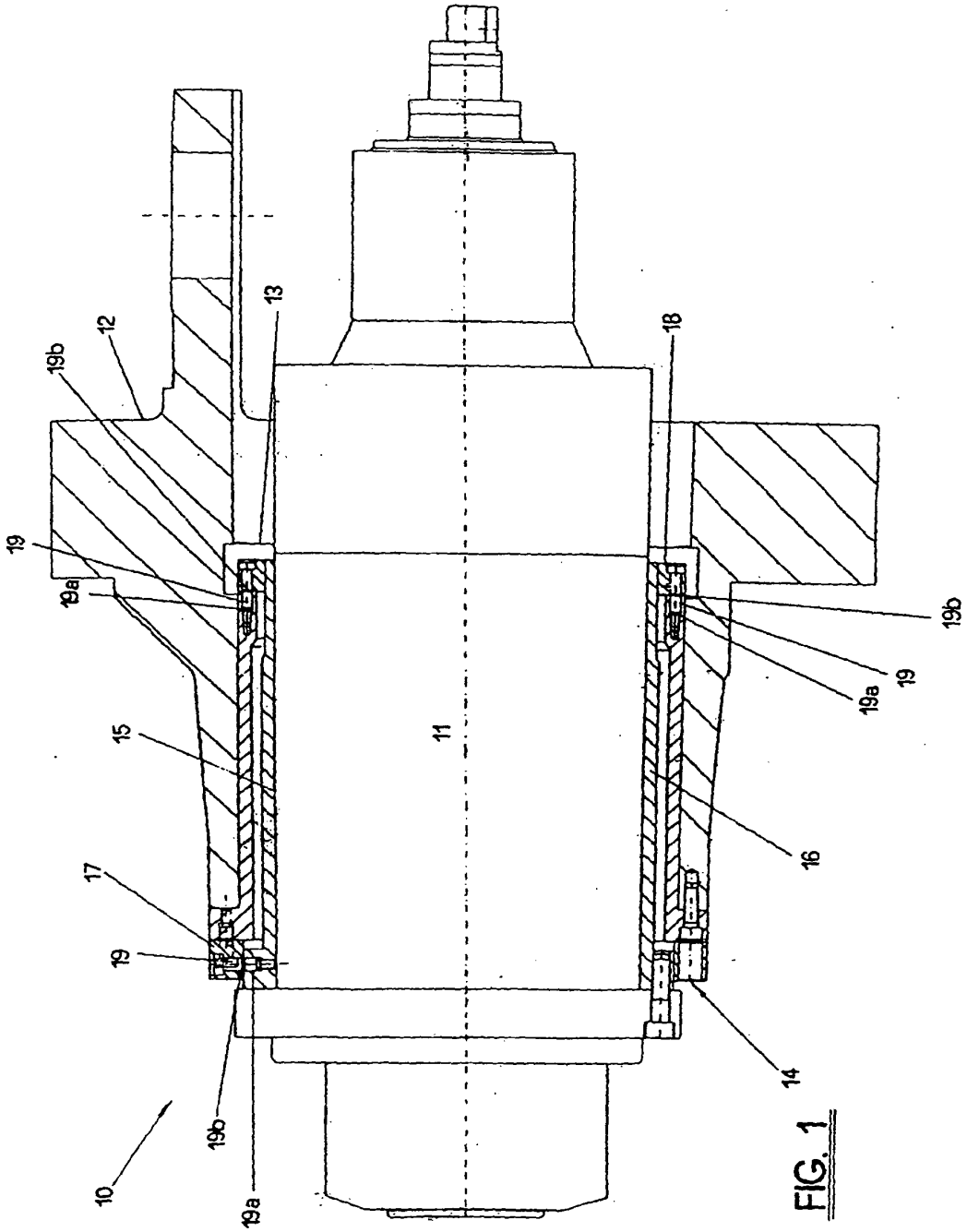
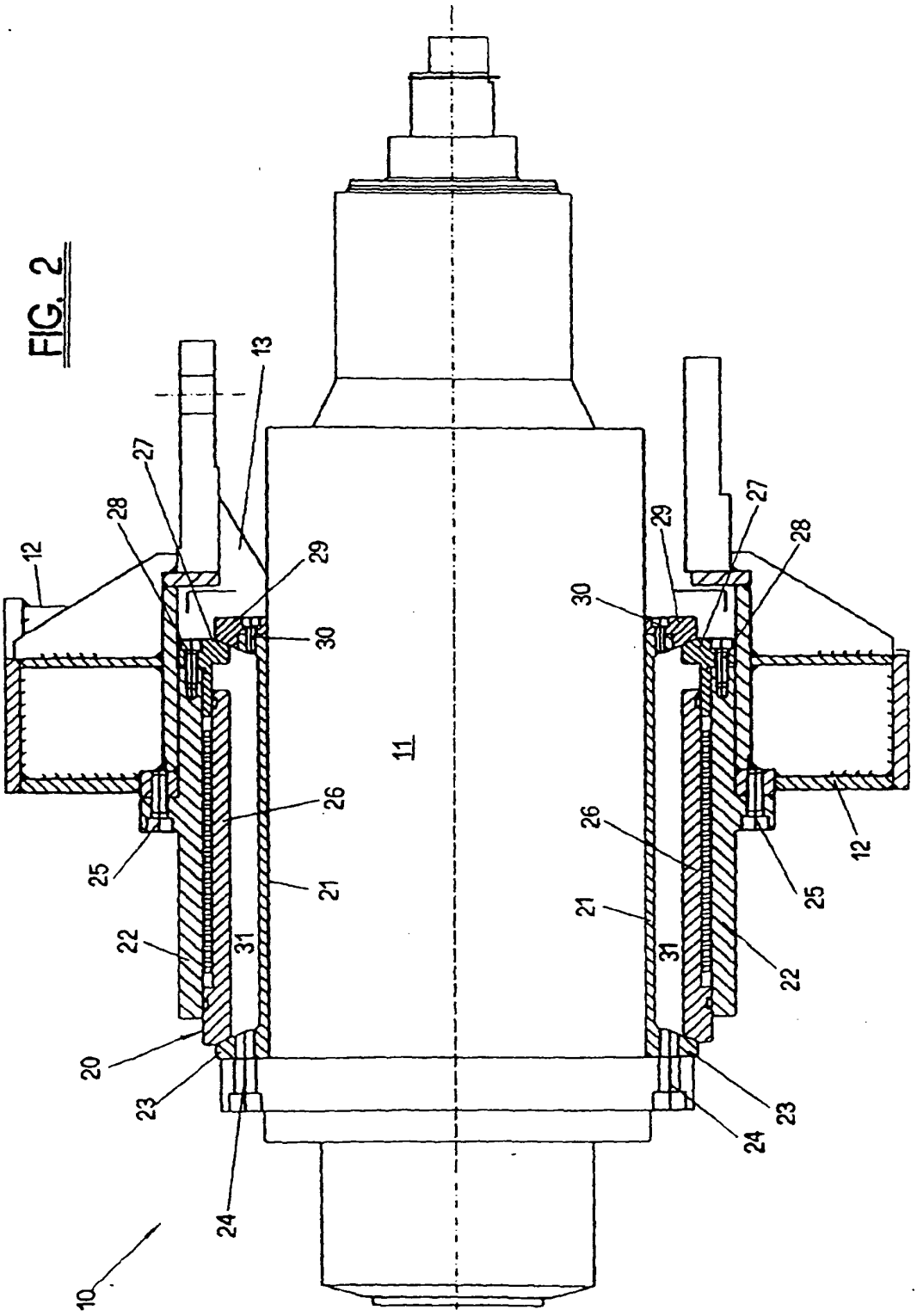


FIG. 1

FIG. 2



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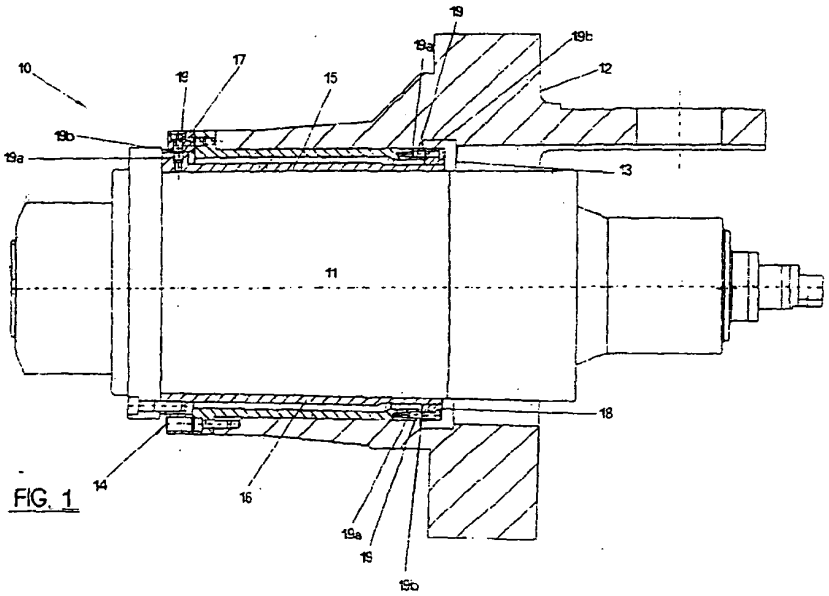

FIG. 1

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 12 2674

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 April 2002	Ljungberg, R

CATEGORY OF CITED DOCUMENTS

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